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STUDIES ON LARVAE OF CRABS OF THE FAMILY GRAPSIDAE

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INTRODUCTION.

The material on which the original descriptions and drawings of this paper are based was collected at Beaufort, N. C., during the summers from 1916 to 1922. The egg-laden females were kept in crystallization dishes until their eggs hatched. The young zoeas were then drawn with the aid of a camera lucida. They were kept under observation until they died within a few days. The writer acknowledges his indebtedness to Dr. Waldo L. Schmitt, of the United States National Museum, for his generous help in preparing the material for publication.

THE GRAPSID ZOEA.

The only zoeas of this family that have been described thus far are remarkably uniform in structure.[1] A zoea of *Cyclograpsus* is mentioned by Bate and Power but neither a description nor a figure is given. A young form is said to have been described by Cavolini but the writer has not been able to consult the paper. The zoeas referred to below are those of *Sesarma*, *Planes*, and *Pachygrapsus*. These are characterised by the absence of the lateral spines of the carapace and the equal lengths of the antennae and frontal spine. They are very similar to the zoeas of the Ocypodidae from which they may be distinguished by the comparative length of the antennae. These are only two thirds as long as the rostral spine in the Ocypodidae.

[1] Cano describes zoeas that are assigned to *Plagusia*, to *Euchirograpsus*, and to *Planes* (*Nautilograpsus*). He did not secure those of *Plagusia* or *Euchirograpsus* directly from the female and is somewhat doubtful in assigning them. His figures of *Planes* differ so entirely from those of the writer that the two can not be referred to the same species—probably not to the same genus. As the writer secured his zoeas by hatching from a single female in solitary confinement there can be no doubt that they are in truth the larvae of *Planes*.

The larvae described by Cano for *Plagusia*, *Euchirograpsus*, and *Planes* resemble each other closely in the structure of the telson. Those of *Euchirograpsus* and *Planes* possess well developed lateral spines on the carapace. The larva assigned to *Plagusia* does not possess carapace spines. It is highly probable that these larvae should be assigned to another family altogether.

KEY TO KNOWN ZOEAS.

a.[1] Exopodite of antenna a well-formed segment with several hairs.
  b.[1] Basipodites of both first and second maxillipeds with pigment spots ..... *Sesarma cinerea.*
  b.[2] Basipodite of second maxilliped only with pigment spot, *Sesarma reticulata.*
a.[2] Expodite of antenna reduced to a tubercle with a single hair.
  b.[1] Eyes large ..... *Planes minutus.*
  b.[2] Eyes small ..... *Pachygrapsus marmoratus.*

PIGMENTATION.

The color of the pigment in each case is black in the contracted condition and varies from black to reddish-brown to yellow in expansion.

	P. minutus.	*S. cinerea.*	*S. reticulata.*
Anterior rostral	+	+	+
Interorbital	+	+	+
Supracardiac			+
Subcardiac	+		
Lateral to stomach	+		
Lateral to first abdominal segment	+		
Postero-ventral lobe	+		+
Labrum	+	+	+
Mandible	+	+	+
Antenna		+	
Maxillule		+	
Basipodite first maxilliped	+	+	
Basipodite second maxilliped	+	+	+
Dorso-lateral first abdominal segment	+		+
Ventral first abdominal segment	+		
Ventro-lateral second abdominal segment	+	+	+
Ventro-lateral third abdominal segment	+	+	+
Ventro-lateral fourth abdominal segment	+	+	+
Ventro-lateral fifth abdominal segment	+	+	+
Telson	+		

METAMORPHOSIS.

The metamorphosis of the family seems to follow the usual brachyuran formula. There are at least three zoeal stages and there are probably five. Two megalops stages are described. Cano has described the development of *Pachygrapsus marmoratus* up to the early crab stage.

PACHYGRAPSUS MARMORATUS (Fabricius).

The development of this form has been described by Cano (1891). He gives a series of figures that show more details than the description. Cano did not secure his stages by observed molting of known stages and seems to have missed some of the zoeal stages entirely. The zoea seems to resemble that of *Planes* very closely indeed and it is difficult to distinguish them certainly from the description published. Cano did not describe the pigmentation and thus one useful

method of distinguishing closely related forms is not now available. The eyes of *Planes* are relatively very large and its pigmentation unusually heavy. The eyes of *Pachygrapsus* are much smaller.

FIRST ZOEA (fig. 21).

Cephalothorax.—The dorsal and rostral spines are short and stout. Both pass outward perpendicularly to the long axis of the body. Cephalic appendages: The antennule (fig. 27) is a single segment and carries sensory hairs and a seta. The antenna (fig. 27) is in the form of a strong spike that carries an extremely minute exopodite. The spike is hairy near its tip. The other cephalic appendages (figs. 33 and 37) have the usual brachyuran form.

Thoracic appendages.—These have the usual brachyuran form. The first and second maxillipeds carry four swimming hairs.

Abdomen.—The telson (fig. 55) is bicornuate and its horns pass backward almost parallel with each other. There are three spines on the median surface of each cornu. The lateral surface is smooth and does not show a spine.

SECOND ZOEA.

The second zoea is not known. The form described by Cano as the second zoea is doubtless the third stage.

THIRD ZOEA (fig. 22).

The second zoeal stage represented by Cano is probably the third zoeal stage. Cano shows only four swimming hairs on the maxillipeds, but this probably was due to error. They probably had as many as seven or eight hairs. The fact that the scaphognathite is well developed (fig. 38) indicates that the stage is advanced beyond the second zoeal. A more careful examination of this stage probably would show the anlagen of the endopodites of the antennae and of the abdominal appendages.

FOURTH ZOEA.

The fourth zoeal stage seems to have been overlooked by Cano.

FIFTH ZOEA (fig. 23).

The third stage described by Cano shows the condition characteristic of the last zoeal stage. This is the fifth stage in the Xanthidae and Ocypodidae. There are eleven or twelve swimming hairs, the mandible shows a palp, and the thoracic appendages are fully articulated.

Cephalic appendages.—The antennule (fig. 28) shows a base of three segments and, distally, an endopodite of four segments each bearing two or three sensory hairs and an unsegmented smooth exopodite. The coxal segment is enlarged for the statocyst.

The antenna (fig. 28) shows a finger-like bud, the endopodite, the anlage of the future flagellum.

The mandible (fig. 31) bears an unsegmented smooth palp.

The maxillule (fig. 34) shows the solitary epipodital hair on the basipodite. The appendage now reaches its greatest differentiation. Its palp is composed of two segments, and it carries seven or eight long hairs.

The maxilla (fig. 39) also reaches its greatest differentiation. Its palp carries six to nine hairs.

Thoracic appendages.—The first and second maxillipeds show twelve and eleven swimming hairs respectively. The third maxilliped does not have hairs and is rudimentary, but all of its segments are differentiated.

The periopods are rudimentary, although all of their segments are differentiated. The first bears two gills, the second and the third one each.

Abdomen.—The third, fourth, and fifth segments bear short lateral spines on their posterior margins. The sixth segment is separated from the telson. All the segments except the first carry bifurcated appendages. These are smooth as yet.

FIRST MEGALOPS (fig. 24).

Cephalothorax.—The body has the usual shape of a brachyuran megalops. The dorsal spine has disappeared without leaving a trace. The frontal spine is reduced in size but still prominent. The periopods are well developed.

Cephalic appendages.—The antennules and antennae are not described by Cano by word or drawing. The mandibular palp (fig. 32) shows three segments and carries sensory hairs. The maxillule (fig. 35) is considerably altered. Its palp has begun to degenerate. Its joints are lost and it carries a single hair. The maxilla (fig. 39) also has begun to degenerate. Its palp is hairless. The scaphognathite is larger.

Thoracic appendages.—The maxillipeds (figs. 43, 46, and 51) show the usual megalops condition. The exopodite becomes a sense organ and develops a palp terminally. The endopodite is greatly enlarged and with the basal segments becomes an organ of mastication. Gills appear upon the second and third maxillipeds.

The periopods are greatly enlarged and well-formed. They appear elongated and slender and are nearly cylindrical.

Abdomen.—The abdomen is depressed. The appendages are not mentioned by Cano but they probably are typical for the stage.

The telson becomes a flattened plate with a rounded posterior border.

SECOND MEGALOPS (fig. 25).

The second megalops stage differs from the first chiefly in the shape of the cephalothorax. The carapace is shorter, broader, and more depressed. The frontal spine has disappeared and its position is marked by a furrow.

Cephalic appendages.—The antennule (fig. 29) shows three enlarged basal segments bearing distally the two palps. The endopodite is composed of five segments each bearing sensory hairs. The exopodite has two segments, the distal bearing hairs. The antenna (fig. 29) is a single flagellum. The proximal three segments are enlarged. The mandible, the maxillule (fig. 36*a*), and the maxilla are (fig. 41) scarcely changed from the first megalops condition.

Thoracic appendages.—(Figs. 44, 47, 49, 50, and 52.) These show only a few minor changes.

Abdomen.—The abdomen is appreciably broadened and flattened. The appendages (fig. 54) are fully developed as swimming organs.

FIRST CRAB STAGE.

In the first crab stage the cephalothorax has the definite quadrate shape of the family. It is greatly depressed. The abdomen is permanently flexed under the sternum. The periopods are large and flattened.

Cephalic appendages (figs. 30, 36*b*, and 42).—The exopodite of the antennule has disappeared and this appendage as well as the remaining cephalic appendages is in the adult condition.

Thoracic appendages (figs. 45, 48, and 53).—These are now in the adult condition.

Abdomen.—The megalops abdominal appendages are present but are small and shriveled. The adult appendages have not yet developed.

PLANES MINUTUS (Linneaus).

The zoea of this species was known to Thompson who writes that it so closely resembles the zoea of *Eriphia caribbea* as not to merit a separate description or figure. The zoea probably does not occur regularly in the tow at Beaufort. The ovigerous female from which were hatched the specimens here described was brought into the harbor by an unusual combination of wind and tides on June 22, 1920.

The zoea is notable for its minute size (0.9 mm. long and 0.3 mm. dorso-ventrally through cephalothorax), its disproportionately large eyes and long maxillipeds, and its heavy pigmentation.

FIRST ZOEA (figs. 1 and 2).

Cephalothorax.—The dorsal and rostral spines only are present and each is slender and rather short (0.2 mm.). The pigment spots

cover the carapace with a confluent net of black lines when expanded. The eyes are strikingly large and well formed.

Cephalic appendages.—The antennules (fig. 3), mandibles (fig. 5), maxillules (fig. 6), and maxillae (fig. 7) have the typical brachyuran structure. The antennae (fig. 4) are as long as the rostral spine. They appear as stout spikes carrying very inconspicuous exopodites. The distal portion of the spike is covered with minute hairs. The exopodite appears as a tubercle carrying a single hair.

Thoracic appendages.—The first and second maxillipeds (figs. 8 and 9) have the usual structure, with four swimming hairs. They are both very large for such a small zoea. The endopodite of the second maxilliped has three segments.

Abdomen.—The joints of the abdomen are unusually well formed. There are pronounced lateral tubercles on segments 2, 3, and 4 (fig. 10). The telson is typically bicornuate.

Genus SESARMA Say.

The zoeas of the two species of *Sesarma* here described are so similar morphologically that they can be distinguished by their pigmentation only and by a slight difference in size. That of *S. reticulata* (Say) (figs. 13 and 14) is smaller and somewhat more heavily pigmented. It is most readily distinguished by the presence of a pigment spot behind the dorsal spine and the absence of pigment on the first maxilliped. The zoea is 1.3 mm. long and .4 mm. dorso-ventrally through the cephalothorax.

The first zoea of *S. cinerea* (Bosc) is noticeably robust and its olive-green eyes are conspicuous objects. Its length is 1.6 mm. and its carapace depth 0.6 mm. It is best distinguished by the pigmentation of both maxillipeds.

FIRST ZOEA OF SESARMA.

Cephalothorax.—The dorsal and rostral spines are relatively slender and short and the dorsal curves pronouncedly posteriorly. The eyes are perhaps a little smaller than they are usually.

Cephalic appendages.—Only the antennae are not typically brachyuran. They show a well-developed exopodite (fig. 16). The exopodite is a cylindrical segment about one-third as long as the spine. It bears two or three hairs.

Thoracic appendages.—These do not show any unusual feature.

Abdomen.—The lateral border of each segment is produced somewhat posteriorly as a deltoid tooth. The telson is typically bicornuate.

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EXPLANATION OF PLATES.

PLATE 1.

FIG. 1. First zoea of *Planes minutus*, lateral view.
2. Same, frontal view.
3. Same, antennule.
4. Same, antenna.
5. Same, mandible.
6. Same, maxillule.
7. Same, maxilla.
8. Same, first maxilliped.
9. Same, second maxilliped.
10. Same, abdomen, ventral view.
11. First zoea, *Sesarma cinerea*, lateral view.
12. Same, frontal view.

PLATE 2.

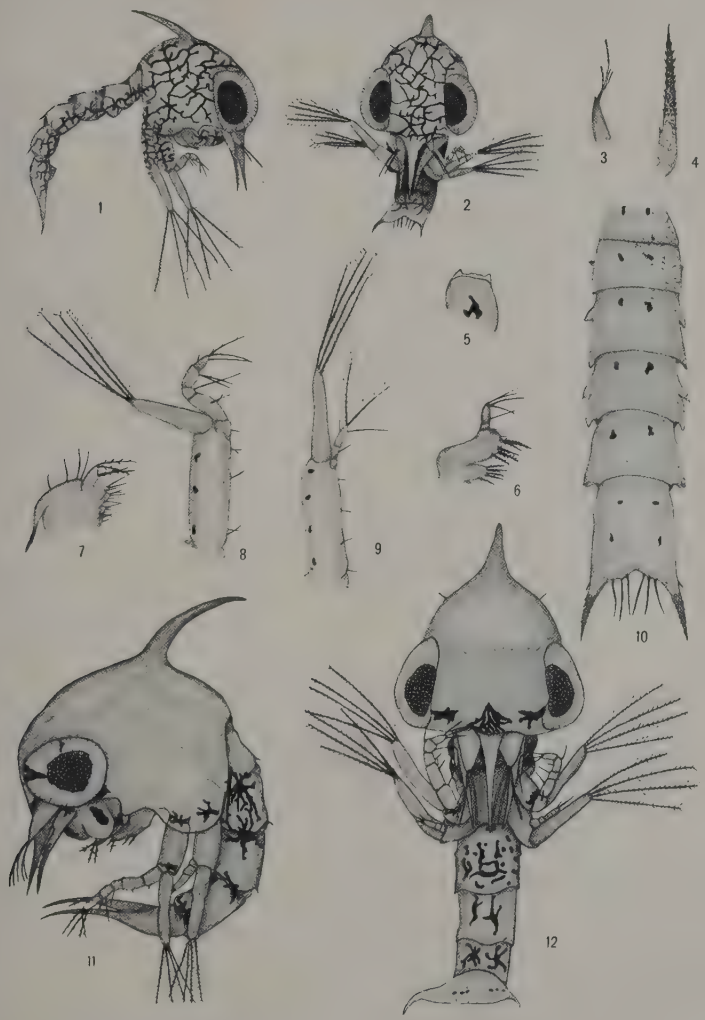
FIG. 13. First zoea of *Sesarma reticulata*, lateral view.
14. Same, frontal view.
15. Same, antennule.
16. Same, antenna.
17. Same, maxillule.
18. Same, maxilla.
19. Same, second maxilliped.
20. Same, telson.

PLATE 3.

Pachygrapsus marmoratus.

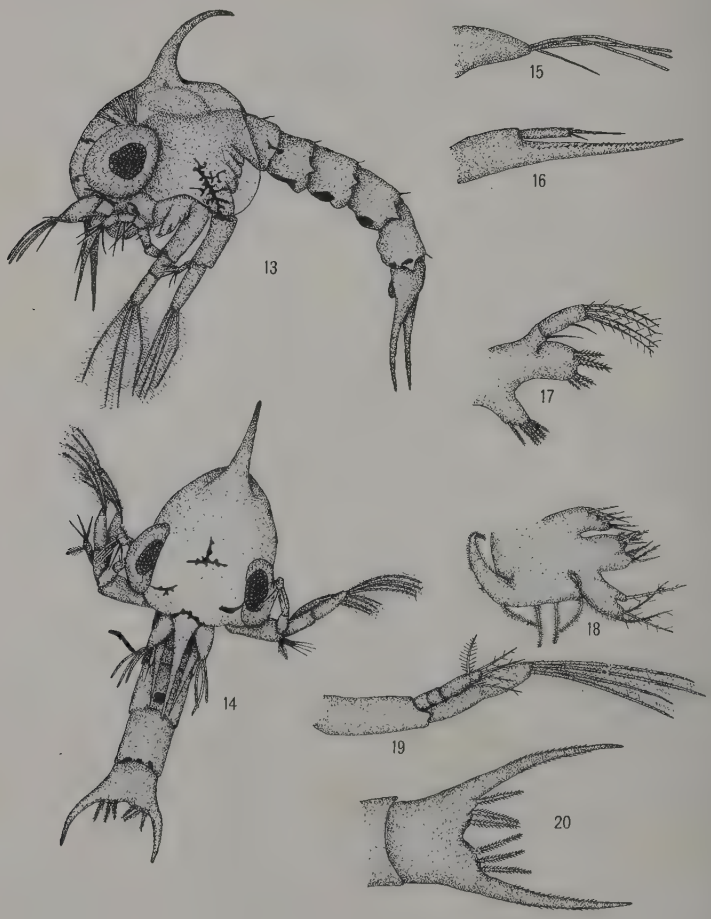
FIG. 21. First zoea, lateral view.
22. Third zoea, lateral view.
23. Fifth zoea, lateral view.
24. First megalops, dorsal view.
25. Second megalops, dorsal view.
26. First crab, dorsal view.
27. Antennule and antenna, first zoea.
28. Antennule and antenna, fifth zoea.
29. Antennule and antenna, second megalops.

FIG. 30. Antennule and antenna, first crab.
31. Mandible, fifth zoea.
32. Mandible, first megalops.
33. Maxillule, first zoea.
34. Maxillule, fifth zoea.
35. Maxillule, first megalops.
36*a*. Maxillule, second megalops.
36*b*. Maxillule, first crab.
37. Maxilla, first zoea.
38. Maxilla, third zoea.
39. Maxilla, fifth zoea.
40. Maxilla, first megalops.
41. Maxilla, second megalops.
42. Maxilla, first crab.
43. First maxilliped, first megalops.
44. First maxilliped, second megalops.
45. First maxilliped, first crab.
46. Second maxilliped, first megalops.
47. Second maxilliped, second megalops.
48. Second maxilliped, first crab.
49. Cheliped, second megalops.
50. Second periopod, second megalops.
51. Third maxilliped, first megalops.
52. Third maxilliped, second megalops.
53. Third maxilliped, first crab.
54. Pleopod, second megalops.
55. Telson, first zoea.
56. Telson, second megalops.



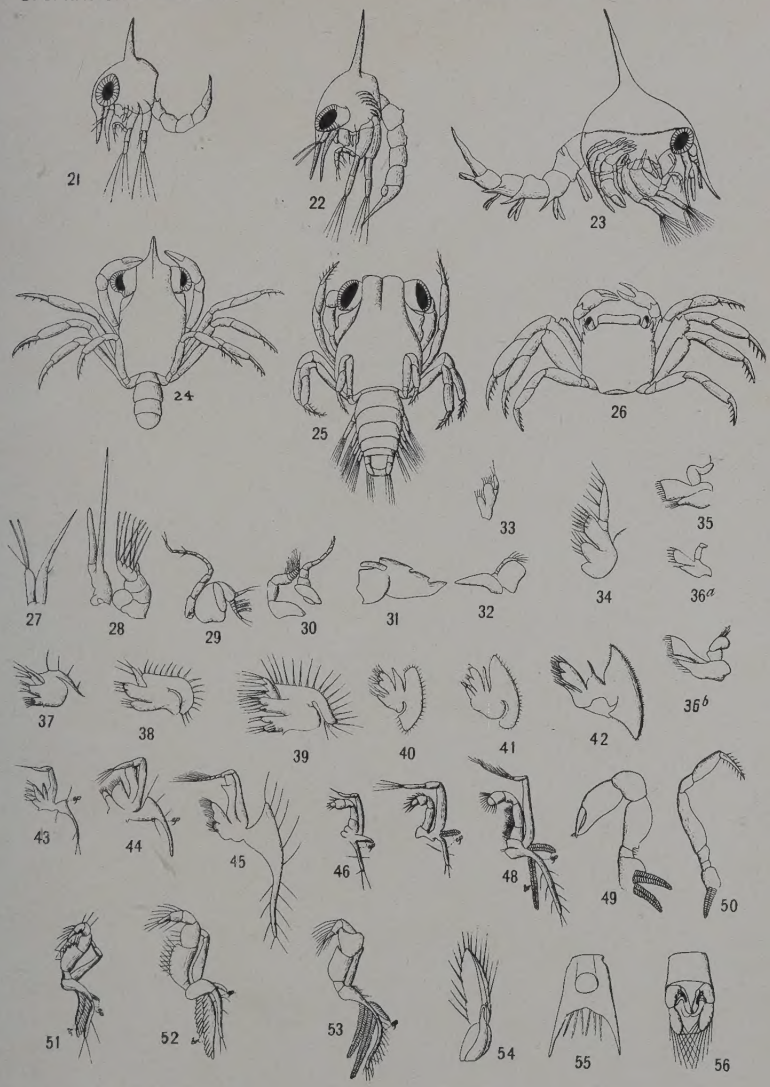
LARVAE OF PLANES MINUTUS (1-10) AND SESARMA CINEREA (11 AND 12)

For explanation of plate see page 7



LARVAE OF SESARMA RETICULATA

For explanation of plate see page 7



LARVAE OF PACHYGRAPSUS MARMORATUS

FOR EXPLANATION OF PLATE SEE PAGES 7 AND 8